Retrograde visceral vessel revascularization followed by endovascular aneurysm exclusion as an alternative to open surgical repair of thoracoabdominal aortic aneurysm

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Staged visceral artery revascularization with occlusion of the proximal lumen enables endovascular exclusion of the entire thoracoabdominal aneurysm from a femoral approach. This technique has been successfully used in three patients at high risk for conventional repair. (J Vasc Surg 2004;39:454-8.)

Over the past four decades impressive reduction in mortality and morbidity associated with open surgical repair of thoracoabdominal aortic aneurysm (TAAA) has been achieved with improvements in anesthesia and surgical techniques.[1] However, this complex and extensive procedure often causes severe cardiovascular stress and altered organ perfusion, which is poorly tolerated by patients with compromised cardiac, renal, or pulmonary function. While the development of endovascular technology is significantly altering the treatment of thoracic and infrarenal abdominal aortic aneurysms, its use to treat TAAA has been limited by the origin of several visceral arteries from the aneurysm itself.

In addition, recurrence of aneurysmal disease makes further direct repeat operative intervention more hazardous than the initial operation. Direct surgical repair of patch aneurysm after previous TAAA repair is also an especially complex procedure in a repeat operative field.[2,3]

In an effort to eliminate the need for aortic clamping and altered distal perfusion, we have established previous mesenteric revascularization from an iliac artery before placement of an endoluminal graft designed to cover the entire TAAA segment.

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Competition of interest: Dr Sanchez is a consultant for Medtronic, Inc.

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CASE REPORTS

The three patients described received treatment under a protocol approved by the Human Studies Review Board at our institution.

Case 1. In May 1999 this 51-year-old woman underwent arteriography because of abdominal pain. Bilirubin concentration had acutely increased from 1.7 mg/dL to 4.9 mg/dL, with aspartate aminotransferase concentration 650 IU. The arteriogram showed occlusion of the celiac, superior mesenteric, and right renal arteries, all originating from a TAAA. Thromboembolectomy of the superior mesenteric artery (SMA) was performed, followed by revascularization of the common hepatic and right renal arteries with a saphenous vein bypass graft from the right iliac artery. All infarcted small bowel was resected, from 4 inches distal to the ligament of Treitz to 10 inches proximal to the ileocecal valve. The resulting short bowel syndrome required long-term parenteral nutrition four nights per week.

Over the next 2 years the type III TAAA continued to increase in diameter, to 65 mm. Because of severe chronic obstructive pulmonary disease and serum creatinine concentration 2.2 mg/dL, the patient was believed to be at high risk for complications after open TAAA repair. A repeat angiogram did not visualize the renal vein graft, and the occluded celiac axis was reconstituted by branches of the proximal SMA, which was highly stenotic at its origin. The right kidney was atrophic, and the left renal artery had high-grade stenosis. In preparation for endovascular repair an 8-mm ringed polytetrafluoroethylene graft was placed intraperitoneally from the left external iliac artery end-to-side to the left renal artery and end-to-end to the SMA. The proximal SMA and left renal artery were ligated to prevent a type II endoleak.

A custom-made stent graft (Talent; Medtronic/AVE, Santa Rosa, Calif) was constructed to cover the descending thoracic and abdominal aorta (Fig 1). The modular graft, including two tho-

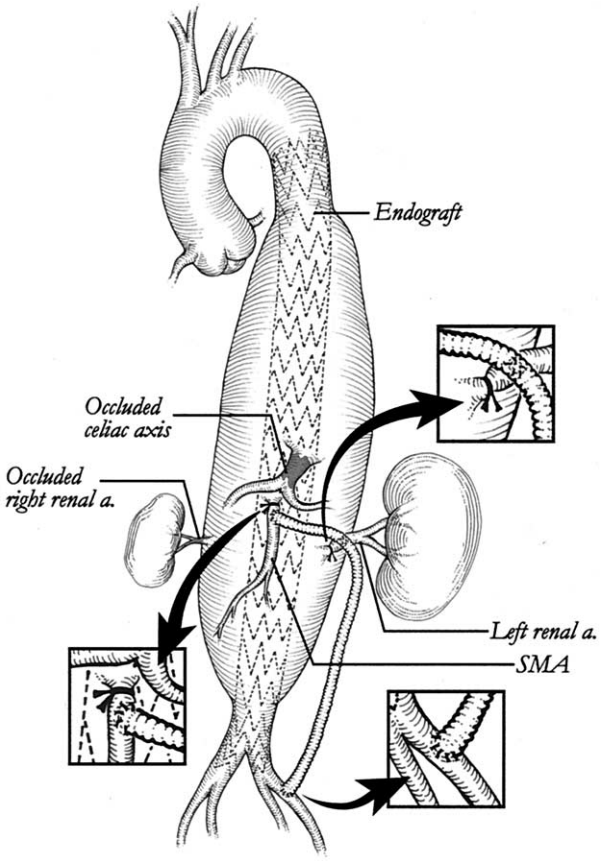

Fig 1. Case 1. Schema of thoracoabdominal aneurysm treated with initial left iliac artery to left renal artery to superior mesenteric artery *(SMA)* bypass graft and subsequent placement of a thoracoabdominal endograft. Proximal superior mesenteric artery and left renal arteries were ligated.

racic components, one bifurcated component, and four iliac extensions, was placed through a 9-mm sheath, from the upper descending thoracic aorta to the distal bilateral common iliac arteries, proximal to the left iliac artery polytetrafluoroethylene graft perfusing the visceral vessels. Acetylcysteine and hydration were given preoperatively for renal protection. General anesthesia without spinal fluid drainage was used. The completion angiogram showed no endoleak, and there was good perfusion of the left kidney and SMA via the left external iliac bypass graft (Fig 2). However, follow-up with three-dimensional computed tomography (CT) reconstruction at 1 year showed a leak secondary to abdominal component separation, which was corrected with insertion of an overlapping component. There has been no further endoleak, and the patient was functioning well with total parenteral nutrition 21 months after initial endografting.

Case 2. In 1996, at age 67 years, this man underwent open repair of a type IV TAAA. A 24-mm × 12-mm woven Hemoshield graft had been beveled to enable the proximal anastomosis to incorporate a patch of the aorta including the left renal artery, SMA, and celiac axis. The right renal artery was occluded, and endarterectomy was performed at the origin of the left renal artery.

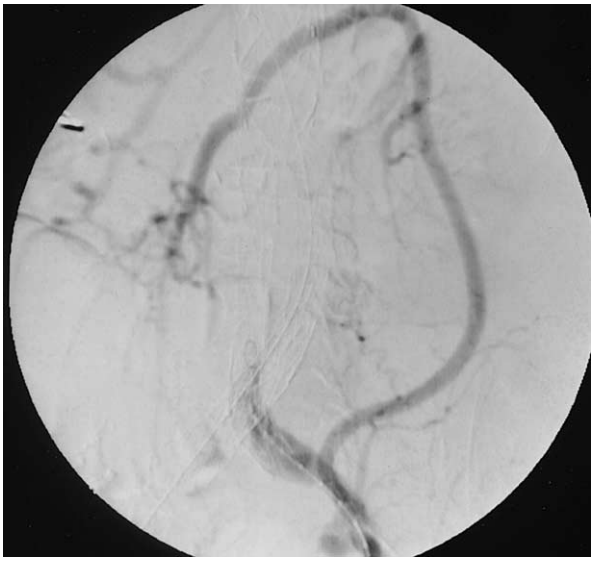

Fig 2. Case 1. Angiogram demonstrates patent left iliac artery to left renal artery to superior mesenteric artery bypass graft.

The bifurcated graft was anastomosed end-to-end to both common iliac arteries. Over 6 years serial CT scans showed that the thoracic aorta above the repair had progressively increased in size to 73 mm in diameter, and the TAAA began several centimeters beyond the origin of the left subclavian artery. The patient had also undergone three coronary artery bypass graft procedures between 1975 and 1991, and there was moderately severe left ventricular diastolic dysfunction. In addition, both internal carotid arteries were moderately stenotic, and the right kidney was atrophic. Serum creatinine concentration ranged from 1.9 to 2.6 mg/dL.

In September 2002 one limb of a 16-mm gelatin-impregnated knitted polyester (Gelsoft) bifurcated graft was placed from the left iliac artery end-to-side to the left renal artery, and the second limb was placed side-to-side to the SMA and end-to-side to the celiac axis (Fig 3). To prevent subsequent type II endoleak, the origins of each of the vessels were suture ligated. A custom-made endovascular graft (Talent) was constructed to extend from just beyond the left subclavian artery to just proximal to the bifurcation of the old abdominal aortic graft. Three weeks later, with the patient under general anesthesia, the endovascular graft was deployed via a bilateral femoral artery approach. Seven Talent graft components were used, each overlapping the other by 4 cm. The first component was deployed with difficulty, because of the arch anatomy, and the second component could not be completely advanced into the first component, because of buckling of the guide wire in the large redundant thoracic aneurysm. Therefore the right brachial artery was isolated, and the femoral artery guide wire was advanced through the right innominate artery to the right brachial artery. Traction on both ends of the wire with sheath protection over the origin of the innominate artery from the arch to beyond the origins of the carotid and vertebral arteries enabled the second component to be positioned with good junction overlap. The completion angiogram demonstrated no endoleak, and the visceral vessels were well-perfused from the left iliac graft.

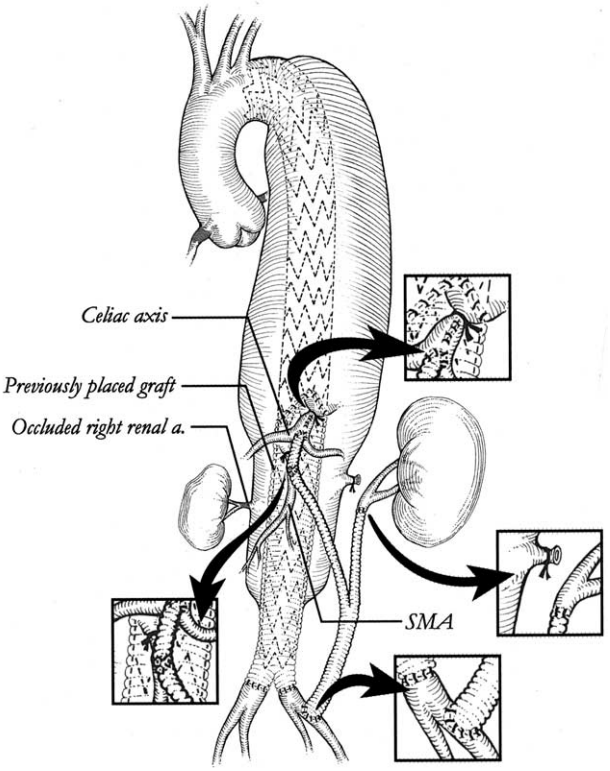

Fig 3. Case 2. Schema of thoracoabdominal aneurysm treated with initial left iliac artery to left renal artery to superior mesenteric artery *(SMA)* and celiac axis bifurcation graft. An endograft was subsequently placed from the proximal descending thoracic aorta into the aortic bifurcation, proximal to the left iliac artery visceral vessel bypass graft.

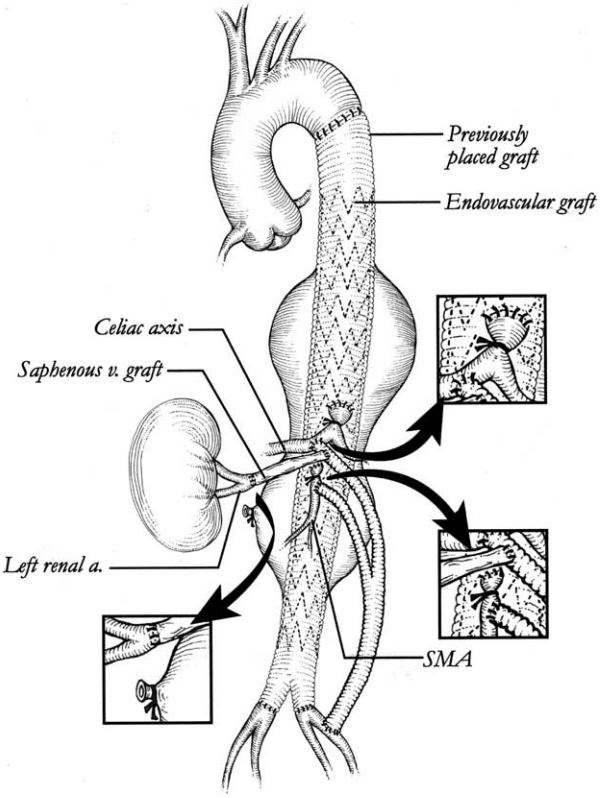

Fig 4. Case 3. Schema of thoracoabdominal aneurysm with aneurysmal dilatation of visceral patches, previously treated with a left iliac artery to superior mesenteric artery and hepatic artery grafts, and a saphenous vein graft to the left renal artery. Subsequently an endograft placed within the descending thoracic aortic graft extended to the old abdominal aortic graft.

Approximately 18 hours after the endograft procedure, dense left-sided hemiplegia developed abruptly. A head CT scan showed only right hemisphere edema. The neurologic deficit completely cleared within 24 hours without neurologic sequelae. Four days after resolution of the neurologic deficit, a repeat CT scan showed resolution of the cerebral edema and no evidence of stroke. The patient has subsequently returned to work, without neurologic sequelae. A follow-up CT scan at 11 months showed the endograft to be well-positioned.

Case 3. Seven years previously, this 50-year-old man had undergone repair of an ascending aortic arch dissection. Two years later he underwent staged repair of an ascending aortic aneurysm and a type II TAAA. Repair of the TAAA included patching of the intercostal, lumbar, and visceral vessels. Recently the patient had new-onset chest and back pain. He also had a history of coronary artery disease, stroke, and severe pulmonary insufficiency secondary to smoking. A CT scan demonstrated aneurysms of the descending thoracic and visceral abdominal aorta. An aortogram confirmed TAAA involvement at the sites of branch vessel reimplantation. While the celiac, SMA, and right renal arteries were not stenotic, the left renal artery was occluded. Serum creatinine concentration was 1.4 mg/dL.

In July 2002, in preparation for TAAA endovascular grafting, a 16-mm × 8-mm bifurcated woven polyester collagen- impregnated graft (Hemashield; Boston Scientific Medi-Tech, Wayne, NJ) was anastomosed end-to-side to the left iliac limb of the previously placed bifurcation graft. One limb of this graft was then anastomosed end-to-side to the SMA, just inferior to the pancreas, and the proximal SMA was ligated. The second limb of the graft was anastomosed end-to-side to the hepatic artery, and the proximal hepatic artery was ligated. The splenic artery was embolized postoperatively. A saphenous vein graft was anastomosed end-to-side to the hepatic artery limb of the bifurcation graft and end-to-end to the right renal artery. Two weeks later, with the patient under general anesthesia, three customized Talent components were placed from the proximal descending thoracic aorta to the bifurcation of the old aortoiliac bifurcated graft via the right femoral artery (Fig 4). Postoperative three-dimensional CT scans demonstrated a small gastric artery type II endoleak, but the aneurysm had decreased in size and the visceral bypass graft was well-visualized (Fig 5). The patient is doing well 12 months after the reconstruction.

DISCUSSION

In an effort to prevent the high mortality associated with repair of ruptured TAAA,[4-6] elective surgical repair of

TAAA is performed more frequently.[1,7] While there has been an increase in operative survival, the incidence of complications and mortality remain high. The presence of a type II TAAA, preoperative renal insufficiency, and left renal artery reattachment are especially associated with increased risk.[8] Patients are at threefold increased risk for acute renal failure with each milligram per deciliter increase in creatinine concentration. Postoperative acute renal failure is associated with higher early and late mortality. As in case 3, the visceral patch remaining after thoracoabdominal aortic replacement, as advocated by Crawford's inclusion technique, is susceptible to further aneurysm expansion and rupture, and presents a significant risk at repeat operation (40% mortality).[3,9]

Current repair of both descending thoracic and abdominal aortic aneurysms with separate endoluminal stent grafts has been increasingly successful, with low risk for paraplegia.[10-11] Trans-graft fenestration stenting has also been used to preserve the SMA and renal flow in the treatment of juxtarenal and suprarenal aneurysms.[12,13] However, completely endovascular treatment of the complex TAAA is still being developed.[12] Chuter et al[14,15] used a 10-component physician-constructed endograft to repair TAAA. The visceral vessel components were inserted through the right brachial artery, and the body of the graft was placed through the femoral arteries. Additional stents in the origins of the SMA and celiac branches were needed to prevent kinking. These complex endovascular branching devices are cumbersome to use, and the success and complication rates associated with these procedures are still to be established.

Limited attempts to combine visceral artery revascularization with endografting have been reported. Quinones-Baldrich et al[16] treated a recurrent type IV TAAA with bilateral renal artery, celiac axis, and SMA revascularization, with simultaneous placement of a Corvita endograft from a right axillary approach to cover the abdominal component and placement of a second graft from the iliac approach to repair the thoracic component of the aneurysm. Passage of a wire from the right axillary artery crossed the arch vessels and risked embolization to the brain. The use of a guide wire from the right brachial artery to the femoral artery was also required in our case 2 to provide a "guide rail" to position the proximal component of the Talent endograft. Although the delayed left-sided hemiplegia probably resulted from this maneuver, the underlying mechanism is unknown, because two CT scans did not demonstrate a deficit that could have resulted from embolization or occlusion. This deficit completely resolved within 24 hours. Special care must be used to protect the origin of the innominate artery from the cutting action of the "clothesline" wire by manipulating the wire within a sheath when crossing arch branches. Smaller delivery systems with better tracking will avoid some of these risky manipulations in technically difficult cases.

Risks associated with this alternative approach include paraplegia resulting from endovascular exclusion of the intercostal arteries, long-term patency of visceral artery revascularization, and durability of the endograft. Our three patients did not have symptoms of paraplegia or paraparesis, despite complete aortic exclusion distal to the subclavian artery. When mesenteric artery bypass grafts have been used to treat ischemia[17,18] the primary patency rate is approximately 90%. If inflow from the iliac artery is not compromised by disease or during manipulation of the endograft, elective preservation of visceral vessel perfusion, as in our patients, would be expected to be better than for patients with occlusive disease. While the durability of synthetic vascular grafts used for open repair has been well-documented, the technology for endovascular graft construction continues to evolve.

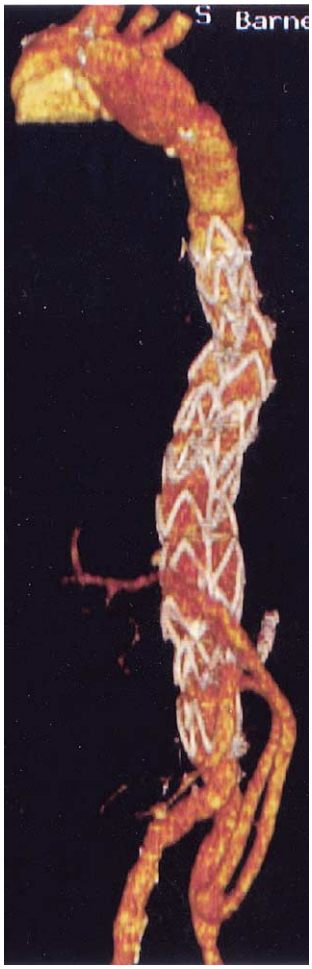

Fig 5. Case 3. Follow-up three-dimensional CT scan shows good perfusion of the visceral vessels via the left iliac artery graft after placement of the extensive endograft excluding the thoracoabdominal aneurysm.

In three patients with TAAA who were considered at high risk for conventional open repair, we performed retrograde revascularization of important visceral vessels before subsequent endovascular exclusion of the entire aortic aneurysm, which may extend from the left subclavian artery into the iliac arteries. These longer multicomponent en-

dografts are at greater risk for separation as the configuration of the TAAA changes. Therefore extensive overlap of the longest available components should be used to minimize the number of component junctions. This combination of standard open intra-abdominal revascularization and endovascular grafting enables staged treatment of complex TAAA in patients considered to be at high risk for open repair.

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